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THE UNIVERSITY OF ALBERTA

A COMPARISON OF VARIOUS TYPES OF BOXING GLOVES
ON THE BASIS OF CERTAIN IMPACT MEASURES.

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS

FACULTY OF PHYSICAL EDUCATION

by

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EDMONTON, ALBERTA.

JULY 1965

APPROVAL SHEET

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "A Comparison of Various Types of Boxing Gloves on the Basis of Certain Impact Measures" submitted by Robert Joseph Piau in partial fulfilment of the requirements for the degree of Master of Arts.

ABSTRACT

The purpose of this study was to compare three types of boxing gloves on the basis of two measures resulting from impact, and to analyze the data of each measure using analysis of variance, the Duncan New Multiple Range Test and the t-test.

The methodology was to impact the different gloves which all had the same initial potential energy at the instant the target was struck. The boxing gloves were fitted unto a wooden fist installed at the end of a three foot metal pendulum weighing 10.036 pounds. Adjustable weights could be added or taken off in order to keep the lever at a constant weight (10.036 pounds) for whatever gloves were tested.

At the end of its fall the glove contacted a target which consisted of an aluminum sheet. The latter was deflected upon impact and a strain gauge which was attached gave a measure of deflection. This information was fed into an oscilloscope and photographed. From this, the energy absorbed by the glove was calculated.

Following a pre-test, an endurance test was run with the best glove of each type of 8 oz. boxing gloves. Two readings were taken, after the first, second and third hundred blows were struck against a wooden board. The types of gloves and the gloves within each type were ranked according to their ability to absorb impact energy.

A comparison between 8, 10 and 12 oz. gloves padded with a combination of foam rubber and coarse hair was

completed. The surfaces of impact of the gloves were also calculated.

It was concluded that in general, foam rubber gloves were superior to the coarse hair and the combined foam rubber and coarse hair types. Furthermore, the 10 oz. glove, padded with a combination of foam rubber and coarse hair, absorbed more impact energy and therefore offered more protection than the 12 ounce boxing glove of the same type. However, it should be emphasized that only two gloves of each 8 oz. type and one glove for the 10 oz. and 12 oz. were tested.

ACKNOWLEDGMENTS

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CHAPTER I

STATEMENT OF THE PROBLEM

Introduction.

Boxing is a very controversial sport. Some critics even say it should be banned. Recent fatalities and serious injuries seem to have dramatized the danger of boxing. There is a recognized risk of disability and death in every sport, including boxing, which becomes apparent when a fatality occurs and is widely publicized.

Boxing can be regarded from two points of view: professional and amateur. Professional boxing, like any professional sport, is a means and a way to earn a livelihood. In order to make enough money to live, the professional boxer sometimes has to box to the detriment of his personal health and well-being.

On the other hand, amateur boxing can be regarded as a true sport and not as a profession. It is one of the recognized Olympic sports. The following is a definition of an amateur as stated in the A.A.U. of Canada rules governing boxing (1: Part II rule 2):

An amateur is one who has never competed for a money prize, staked bet, or declared wager; who has not competed with or against a professional for any prize (except with the express sanction of the Amateur Boxing Association of the nation of which he is member) and who has never pursued or assisted in the practice of athletic exercises as a means of obtaining a livelihood or for pecuniary gain. Athletic exercises are all kinds of sports administered by a recognized Amateur Federation of National Associations,

According to Grant (22), the benefits of boxing to a boy's and young man's health are both psychological and

physical. He states that (22:6):

There is no doubt that psychologically boxing benefits inadequate, insecure and aggressive boys alike, affording them both the opportunity to develop discipline, self-control, and the art of self-defence. The physical training and road work required of a conscientious boxer and the moderation needed in smoking and drinking, lead to physical fitness and good health.

Boxing gives pleasure to many thousands who appreciate the agility of a good boxer who avoids punishment by blocking and slipping under punches and by fast footwork.

In an answer to juvenile delinquency I believe it can play an important part by being the outlet for psychopathic traits - such as aggressiveness and feelings of inadequacy and inferiority as mentioned above.

Along the same lines, Parker and Trifunov postulate that (24:433):

Human nature being what it is, man's natural antagonism will for some time yet require an outlet for expression. Social workers and the courts can supply ample evidence of the ways in which some youths rid themselves of this unfortunate tendency. Organized and properly controlled competitive boxing appears to be an excellent way of guiding antagonistic and antisocial attitudes along the right channels. It is interesting to note that the majority of youths who enter boxing and most often make it a career are from low-income families and frequently from disrupted families. The training prerequisites for boxing include rigorous physical and mental discipline. To lose one's temper with an opponent in the ring is often a reason for being defeated. If supervised correctly, perhaps boxing can be used to strengthen a young man's character and make him a better citizen.

Even though one may or may not agree with the advantages or disadvantages of boxing, it remains a fact that boxing is a sport, and in particular, amateur boxing can be considered as such.

Therefore, physical educators should know when and how to use boxing in the program and should be concerned in using

the best equipment available in order to avoid injuries and to obtain the maximum benefit from this activity.

The devices developed to protect individuals from injuries reflect the philosophical approach of a culture to combat, and indicate the level of its art and science. Within the past decade, associated with an increasing public interest in sport and physical fitness, an awareness of the importance of protective equipment in various sports has arisen. Laboratory studies are carried out today to improve sport equipment in design and basic construction, which emphasise the importance which is now given to good equipment as a basic factor in the prevention of injuries.

The Problem.

The present problem is to compare the capacity of various types of boxing gloves, padded with coarse hair, foam rubber and a combination of both types of padding in absorbing the impact energy of a standardized blow. The sub-problems to be investigated are:

1. To compare the surface of impact of the different boxing gloves.
2. To determine the change in the capacity of some boxing gloves to absorb impact energy after an endurance test.
3. To compare the capacity of some 8, 10 and 12 oz.

boxing gloves padded with a combination of coarse hair and foam rubber in absorbing the impact energy of a standardized blow.

Assumption.

Given that all the different gloves will have the same

initial potential energy at the instant the plate is struck, the glove that will deflect the plate the least will absorb the most impact energy.

Definition of Terms.

For the purpose of this study, the following definitions apply:

1. Gloves Type I: gloves padded with a combination of foam rubber and coarse hair. (gloves 1 and 2)
2. Gloves Type II: gloves padded with coarse hair. (gloves 3 and 4)
3. Gloves Type III: gloves padded with foam rubber. (gloves 5 and 6)
4. Glove 6 (Type III): glove padded by the experimenter with a combination of two foam rubbers.

Limitations of the Study.

The results and conclusions of this experiment will be limited by:

1. The sample of boxing gloves studied.
2. The methods and materials employed in the study.
3. The experimental errors of the investigator.
4. The statistical procedures used to analyse the data.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction.

In the recent years, many new items of sports equipment have appeared on the market as a result of laboratory research. Athletes and sportsmen can now, for example, use improved release bindings in skiing, better helmets in football, baseball and hockey, while wrestlers and boxers can practice their favorite sport on safer mats.

Very little research seems to have been done up to the present, however, concerning the main piece of equipment used by the boxer, that is, boxing gloves, since they were first worn on October 8, 1818 (9).

The rules of the A.A.U. of Canada (1958) stipulate that the following conditions are mandatory concerning the boxing gloves themselves (1):

The gloves shall each weigh eight ounces, of which the leather portion shall not weigh more than four ounces, and the padding not less than four ounces. The padding of the gloves shall not be displaced or broken. Only clean and serviceable gloves shall be used.

The question as to whether or not the padding should be increased in the gloves to make boxing safer is not agreed upon by different authors. Some seem to believe that an eight ounce glove used today in amateur boxing is the optimum weight for a boxing glove (13:22), others argue for an increase in the padding (24), while others assert that there should be a decrease of the padding (15, 10, 25, 16). A few statements found in the literature concerning these opinions are:

1. The regulations currently in force in Germany, informed by a very real concern for the boxer's health, include

the following points:

.....
2. Eight ounce standard gloves to be used to avoid injuries caused by uneven padding and weight (13:19).

2. In modern amateur boxing the use of eight ounce glove has almost abolished open wounds... (22:46).

3. The weight of gloves issued in amateur contests should be increased to 10 ounces from the previous 8 ounces. This will reduce the incidence of knock-outs and severe injuries (24:435).

4. The boxer should be made to wear sufficiently, heavy gloves and wear material of a caliber to prevent anything like a knock-out (15:5).

5. Les blessures au visage et les fractures des mains sont imputables aux gants dont se servent actuellement les boxeurs. Il s'agit donc pour nous de protéger les surfaces vulnérables de la boîte crânienne et de parer au danger des blessures et fractures en modifiant les gants.

A cet effet, je soumetts à votre approbation des modèles de casques et de gants de conception nouvelle.

Dans le gant (pneumatique) une vessie remplie d'air tient lieu de rembourrage. Autre innovation, le boxeur est obligé d'introduire son pouce à l'intérieur du gant. Des essais ont été effectués avec ce modèle et nous ont permis de constater que la force des coups est diminuée de 50% et qu'il n'y a pratiquement plus aucun risque de K.O. ou de blessure.

Le casque de protection est également pneumatique et de fixation aisée. Il protège parfaitement le front, la tempe et la nuque (zones vulnérables) (8:25-26).

6. The Committee on the Medical Aspect of Sports of the American Medical Association also recommends careful consideration of the following measures:

.....
2. Experimentation with less padding in the gloves so that the threat of damage to the hands will inhibit the power of the blow (10:242).

7. En ce qui concerne les fractures des mains, j'ai constaté qu'elles sont dues aux chocs produits sur la surface dorsale de la main, laquelle n'est pas soutenue par la face palmaire. Je pense qu'il serait plus avantageux d'adopter le principe de placer un rembourrage de plastic léger sur la partie du gant correspondant à la face palmaire, afin de doter celle-ci d'un soutien (25:24-26).

8. The live force of the fist already considerably mitigated by the thickness of the gloves and their soft

padding, is generally insufficient to cause an elastic deformity of the skull. It does, however, give rise to a series of traumatic waves which are transmitted from the site of impact to the brain mass, their size being proportional to the extend of the area affected (16:90).

9. The cerebral knock-out must be prevented by giving instructions to the referee to promptly stop the fight at the first signs of functional nervous troubles, and by modifying the gloves in relation to the premises of the traumatic mechanism. The hitting surface must not be amplified; for this purpose the padding has to remain limited to it, and the fist be permitted to close (which also protects the hands) (17:346).

10. L'usage de gants munis d'un épais rembourrage a été adopté en vue d'éviter: a) les fractures des mains pour celui qui frappe; b) les lésions encéphaliques et les blessures du visage à l'adversaire. Or, ces deux buts n'ont pas été atteints.

Si les gants atténuent la force vive des coups, ils augmentent, par contre, la surface d'impact. Pour remplir les conditions voulues, ils doivent être conçus de façon à permettre la fermeture complète du poing (élimination des fractures). Ils doivent aussi être munis d'un rembourrage indéformable et susceptible, par la nature de ses composants, d'atténuer la force vive des coups. Enfin leur surface d'impact doit être aussi réduite que possible (18:24-26).

11. Certains affirment aussi, avec raison semble-t-il, que l'emploi de gants plus gros (6 ou 8 onces selon les pays au lieu de 4 onces autrefois) est responsable de trop de massacres. Cette réforme fut pourtant adoptée pour "humaniser" la boxe. Or, jadis, quand les petits gants étaient utilisés, les boxeurs devaient posséder à fond l'art de la défensive afin d'éviter les coups qui pouvaient être la plupart décisifs. Les mauvais boxeurs, les faibles, étaient ainsi très tôt éliminés. D'autre part, un K.O. dans les premiers rounds est souvent moins dangereux pour l'organisme qu'une terrible punition pendant 10 rounds ou plus, même quand le boxeur termine debout. L'usage des gros gants permet à des hommes, dits "encaisseurs", de tenir la limite bien que sur-classes (14:39).

12. The legislators determined to bar fights with bare knuckle battles, under London Prize Ring Rules, because they had the idea they were brutal, while modern boxing was the "manly art of self-defence". The practical truth is that present day fighting, with gloves encasing fists, and with rounds made up of three minutes each, are more devastating and admit more bestiality, than ever were known in bare knuckle fighting.

.....
A few hundred other ringmen have gone to their graves because of the horrible beatings they had to take, from gloved fists, during the three minutes, which make up a round of boxing today.

.....
In contrast, it is difficult for anyone to name a dozen, a half dozen, or even a few instances of death resulting from those "brutal" bare knuckle contests under London Prize Ring Rules. Man took beatings, but never anything comparable with what others have taken in "boxing bouts" where gloves do little more than protect the fist of the striking fighter, and where the rules require a man to withstand a blizzard of punches, lest he goes down, and be counted out (23:240-241).

13. So-called safety measures requiring ten ounce gloves in all classes, round-by-round medical examinations and other modifications do not obviate the dangers of boxing (6:88).

It can be noted, after having read these different statements, that the opinion range is from one extreme to an other. Since no scientific research evidence seems to support any point of view previously mentioned, the author feels that there should be a study done on boxing gloves involving different kinds of padding in order to try to clarify the problem.

Only one study pertinent to this subject is reported. In 1961, Löfgren (19), in Finland, constructed and introduced a new kind of boxing glove, the pneumatic glove, which weighed 12 ounces and was of the same size and form as the standard glove used in Europe. The inventor of this glove set up an experiment whereby the pneumatic glove was compared with a standard one. The testing procedures were reported as follows (19:26):

By means of a pendulum movement, a constant velocity was given to the glove which was fitted on to a wooden

model of a fist. At this velocity the glove met a mass, also fixed to a pendulum to which an induction vibration indicator was attached. Two series of tests were carried out:

a) In the first series the mass of the fist pendulum was about 20 kilograms and its velocity about 12 metres per second.

b) In the second series, the mass was about 6 kilograms and the corresponding velocity about 5 metres per second. The electric current excited in the indicator by the blow was led into an oscilloscope. The extent of the acceleration given to the indicator by the blow could be judged from the coefficient of the angle of the rising part of the curve shown on the screen of the oscilloscope. In all measurements only the relative acceleration was observed.

According to Löfgren (19), the results of his experiment have indisputably shown the superiority of the pneumatic glove compared to the standard glove, as regards the protection against trauma. The experiment, in his opinion, showed that the pneumatic glove fulfils and even surpasses the requirements which can reasonably be placed on a glove, the main purpose of which is to reduce the force of the blow.

Löfgren is not very explicit as to what he means by a standard glove and it is apparent that further investigation should be undertaken using different weights of boxing gloves, padded with coarse hair, with foam rubber, with a combination of foam rubber and coarse hair, and manufactured by different companies in order to compare them with the pneumatic glove.

It must also be added that the pneumatic glove was further criticized by the few countries which had availed themselves of the opportunity to use it (4:46); answering a questionnaire concerning that matter, the German Democratic Republic and Great Britain both replied that they found the glove unsatisfactory. Australia replied that they had been

using the glove for many years. It was suggested that manufacturers be asked to produce a smaller pneumatic glove for further trials.

Further to this, England decided to manufacture such a glove which would weigh 7 3/4 ounces. This new pneumatic glove was the one the author intended to use in the present study. Unfortunately, this glove was not yet available when this study was begun.

Studies of Impact on Sport Equipment.

Up to more recent years, many of the deaths in boxing were caused by falls backward resulting from blows to the head. The rule of the "Association Internationale de Boxe Amateur" (A.I.B.A.), of the 1958 edition, concerning the floor of a ring is stated as follows (1):

The floor shall be covered with felt, rubber or other suitable approved material having the same quality of elasticity, not less than half an inch (1.5 cm) and not more than three quarters of an inch (1.9 cm) over which canvas shall be stretched and secured in place. The felt or other approved material and canvas shall cover the entire platform.

Because felt seemed insufficient to lessen the effect of blows to the head, new materials such as surbo rubber were used in many places (20:17). This fact had been established empirically only. Further to this, Löfgren conducted a scientific study where he compared the ability of felt to reduce impact with five different constructions of foam plastic and wallboard.

In each case a canvas was stretched over the under-cover as required by the International Rules. A wooden ball ("the head") of three kilograms was fastened with a joint representing the flexible "neck", the end of the

metal pole, 1.7 m. in length. The back of the "head" was sheathed with a thin rubber membrane. To this part, an accelerometer was attached. The meter was connected to a screen of an oscillograph in which the resultant signal was photographed. The drop of the wooden "head" varied from 25 cm to 80 cm (20:18).

The results of this experiment were that all five under-covers tested were far more efficient as to their ability to lessen impact than felt, not to mention the bare floor.

In another study on football helmets, for protection against the accelerative effects of the brain of high levels of impact energy, Snively, Kovacic and Chichester also used a testing device with an accelerometer (26:223).

The helmet to be studied is placed upon a metal test head in which is fitted a crystal-type accelerometer. A known amount of impact energy is applied by dropping upon it a striking bob; the weight of this bob and the height of its drop are easily varied. The head support pivots upon impact, thus providing for an essentially free-moving mass. Acceleration imparted to the test head is translated into an electrical impulse, magnified by an amplifier, impressed upon the screen of a cathode ray oscilloscope, and photographed by a Polaroid Land camera.

As a result of this experiment, a prototype of a football helmet utilizing an energy absorption design similar to a racing helmet was developed and found to have superior energy handling ability in the laboratory as well as an appreciable gain in comfort under both practice and game conditions.

Lombard, Ames, Roth and Rosenfeld (21) performed an experiment in which they studied the voluntary tolerance of the human to impact accelerations of the head. Their testing apparatus also included an accelerometer (21:109).

In order to deliver blows to the head with equipment which might in turn yield information as to the accele-

ration imparted to the head, it was deemed necessary to use a pendulum of mass approximately equal to that of the head and headgear.

.....

In the steel head of the pendulum was mounted a strain gauge type accelerometer capable of measuring in excess 500 G. and having a frequency response of over 3,000 cycles per second. The output from this accelerometer was amplified in the pre-amplifier stage of an Offner electro-encephalograph and fed directly to the plate of a cathode-ray oscilloscope tube.

.....

The face of the oscilloscope was photographed by a 35 mm. streak camera at a film speed of approximately 16 inches per second. Time correlation was obtained by the simultaneous recording on the film of a small neon bulb flashing at 1/100 second intervals.

The result of this experiment (21) showed in general that the upper limit of linear acceleration which the human can tolerate voluntarily due to impact blows to the head has not been reached, in spite of the fact that blows giving as high as 38 G. (1224 feet per second ²) have been reported. The effect of the locally applied force causing bruising, tension loads on the ligaments or ligamentous attachments of the neck muscles, or sharp burning pains in the joints of the cervical vertebrae always caused the subjects to voluntarily and/or subjectively limit exposure to no higher energy impacts.

Doing an evaluation of thirteen brands of football helmets in 1960, Alexander (2), used a wooden head suspended from the ceiling by two steel cables and in which was placed an accelerometer. The helmets were fitted unto this head and impacted by a flat surface pendulum at the back of which was also an accelerometer. The output from these accelerometers was fed into a dual trace oscilloscope, photographed, projected, analyzed, and calculated in Gs and Gs per second.

It was concluded that, in general, leather and rubber shelled helmets were inferior to the plastic-type helmets. Helmets with pliable plastic-type shells and padded suspension liners were superior to hard brittle shells with canvas suspension liners.

In 1963, Bazzano (7) studied three different brands of boxing headgear (Wilson H 1900, McGregor G 466 and Tuf-Wear) and compared them with a molded liner of a football helmet made of expanded polystyrene foam.

To accomplish the above he used a double pendulum consisting of two suspended steel balls each weighing 16 pounds. Bearings were situated at the point of rotation in order to have a constant friction. The angle of displacement of the receiving ball was measured by an electrogoniometer.

The headgears studied were placed on the stationary ball. They were then hit on the front pad from different angles. Ten trials were given at each of the different angles.

The results showed that the expanded polystyrene foam was superior to the other types of headgears studied. The difference was found to be statistically significant.

It was further noticed that after a few blows on the same spot, styrofoam tended to lose its absorbing power. As pointed out by Bazzano (7), this could mean that a styrofoam headgear would offer superior protection for one bout only. On the other hand, with the use of boxing gloves, the striking area of the fist is larger than the one of a steel ball. Furthermore, the glove itself absorbs a great amount

of impact energy and therefore reduces the chance of damaging the headgear.

CHAPTER III

METHODS AND PROCEDURE

The equipment studied was the following standard boxing gloves:

- a) gloves padded with coarse hair: 2 eight ounce manufactured by different companies.
- b) gloves padded with foam rubber: 2 eight ounce gloves.
- c) gloves padded with a combination of both types of padding: 2 eight ounce gloves.

It was the intention of the writer to study larger samples of each type of boxing gloves and to include the pneumatic type of glove in this study. Unfortunately, most of the companies contacted failed to cooperate and send requested information and gloves.

As far as the pneumatic glove was concerned, it was not available when this study was begun. More information concerning these points are found in the appendix.

Experimental Equipment.

The impacting device consisted of a three foot metal lever weighing 10.036 pounds and at the extremity of which was fixed a wooden fist. The latter was equipped with a small lever which acted as the fingers of the hand. Due to a spring controlling it, the lever could remain extended or could be closed toward the inside of the hand in order to keep a boxing glove well clenched.

The striking arm was always dropped from the same angle ($29^{\circ} 39'$) and was provided with adjustable weights so that whatever glove was tested the weight of pendulum was always

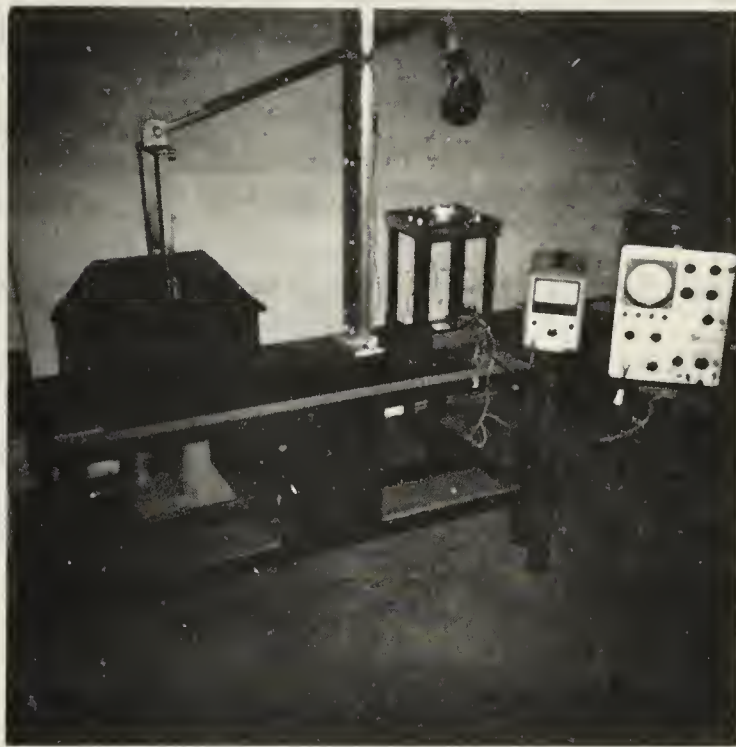


Figure I. Impact and Recording Devices.



Figure II. Wooden fist with lever (fingers) extended.



Figure III. Wooden fist with lever closed.



Figure IV. Boxing glove fitted unto the wooden fist.

the same (10.036 pounds). It was also possible to adjust the lever so that it was always perfectly horizontal when the glove was resting against the surface of impact.

The object against which the glove came into contact at the end of its fall was a .0425 inch thick aluminum sheet. This metal plate was bolted between two metal supports with 16 bolts screwed at 60 lbs/ft torque. The target hit was a circle eight inches in diameter. A strain gauge was placed under the center of the target to give a measure of deflection of the plate.

The operation of the strain gauge was based on the principle that when a piece of wire is strained, the electric resistance is changed, so that this change could be portrayed as a visual signal on an oscilloscope.

The release of the striking pendulum was accomplished by pulling on a "T" shaped support against which it was resting,

Before making contact with the surface of impact, the pendulum triggered a micro-switch which allowed the beam of the oscilloscope to travel on the screen only once. The speed of the sweep was 10 milliseconds/cm and the deflection unit most often used was 1 millivolt/cm. The screen of the oscilloscope was photographed with a Polaroid camera.

The aluminum sheet was calibrated using a microvoltmeter every time a blow was struck.

Testing Procedure.

The gloves to be tested were fitted unto the wooden fist in a standard way. Great care was taken so that the hori-

zontal leather band serving as a grip on the palmar face of the glove was immediately below before closing the fingers (lever).

The height of the striking base was adjusted so that the lever was perfectly level when the glove was resting on the target prior to the test. Following this, the glove was released from a height that was kept constant throughout the experiment.

Before taking the first reading the gloves were given five trials during which the unit of deflection of the oscilloscope was regulated in order to obtain a complete deflection peak on the screen. The next four readings were then recorded.

Following this, an endurance test was run with the best glove in each of the three types which were coarse hair, foam rubber and a combination of both paddings. For this purpose, a piece of wood one inch thick was installed on top of the target and the base of the striking pendulum was raised to keep it level when the glove was resting against the wood surface. The height of the drop was also adjusted in order to keep it the same as in the original testing. The apparatus was brought back to the testing position and two readings were taken, after the first, second and third hundred blows were struck.

For optimal operation efficiency, two technicians were required. The operation of the oscilloscope and camera was controlled by the first technician. Manipulation of the gloves

and release of the pendulum were done by the second.

The surface of impact was obtained after the first four readings. For this purpose, the following procedure was used: the glove was first covered with a thin sheet of polyethylene on top of which was fastened a piece of cloth. Some paint was then applied on the material covering the glove which was released from the original testing height. A print of the surface of impact was obtained and the area of contact was calculated with a plani-meter.

Only one glove of each of the different pairs was studied and was chosen at random.

Calibration of the Apparatus.

Dead weight calibration was made and an empirical formula fitted calibration; Energy of the plate (E_1) = $0.4 D^{2.64}$ (D = oscilloscope deflection in cms.). The energy of system at impact (E_2) was equal to W (weight of pendulum) $\times L$ (length of pendulum at center of gravity) $\times \sin 29^\circ 39'$ (angle of release).

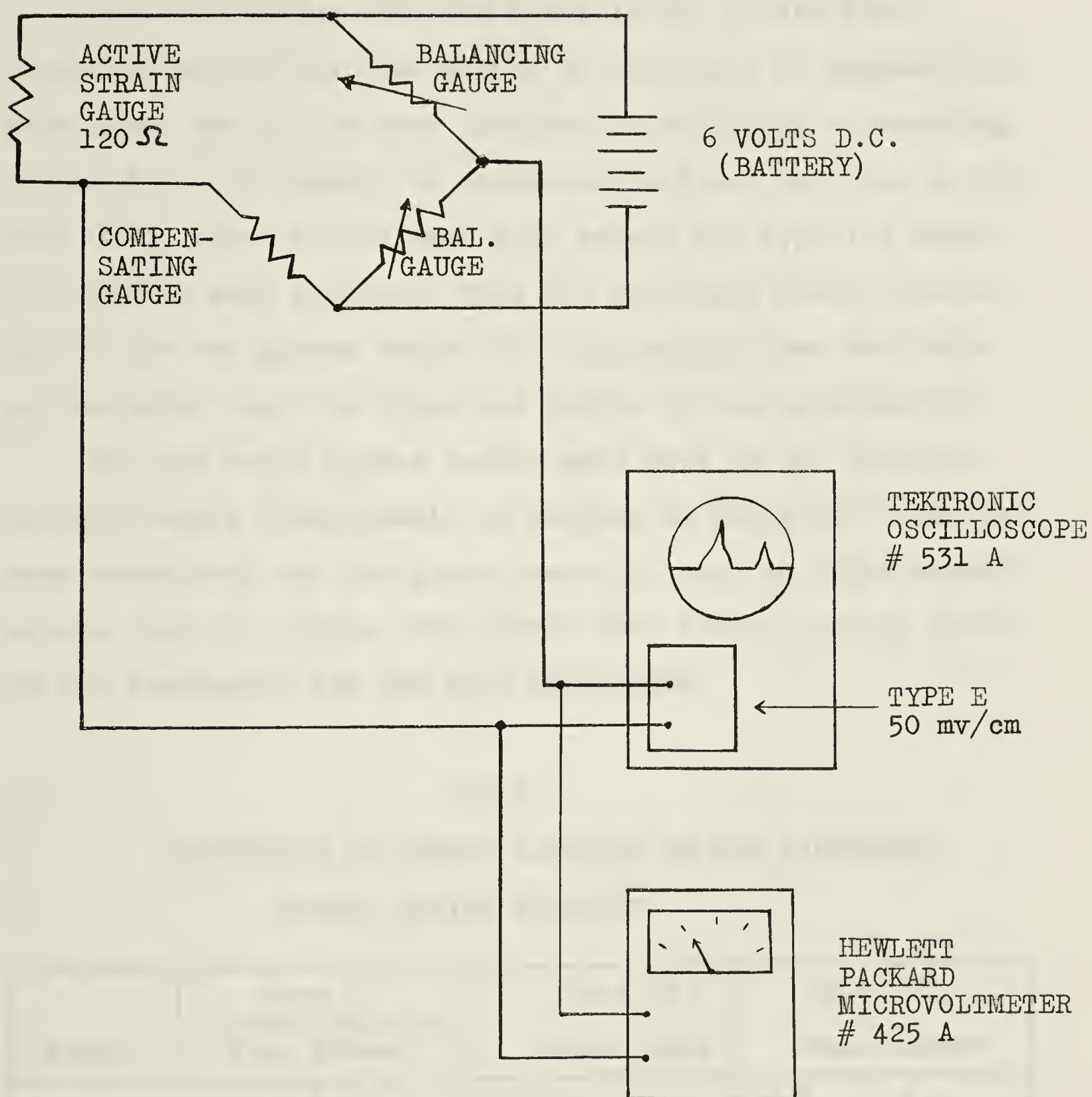


FIGURE V. ELECTRIC DIAGRAM OF THE APPARATUS.

N.B. The microvoltmeter was only connected between blows when calibrating the apparatus.

CHAPTER IV

RESULTS AND DISCUSSION

Tests involving both the 8 and 12 oz. gloves were concluded in one day. Two gloves of each type of composition were used. Due to the cost involved in obtaining a recording of the force of impact, an endurance test was only run on the best 8 oz. glove within each type except for Type III where both gloves were included. Type III were foam rubber gloves. One of the two gloves tested in that category was available on the market and the other was padded by the experimenter.

The ten ounce gloves tested were used in the Canadian Amateur Boxing Championship in Calgary in May 1965. Headgears were compulsory and the gloves were all used by right handed boxers, for six fights. The gloves were tested one day prior to the tournament and two days afterwards.

TABLE I

PERCENTAGE OF ENERGY ABSORBED BY THE DIFFERENT
GLOVES DURING PRE-TEST.

Weight	Type I Coarse Hair and Foam Rubber		Type II Coarse Hair		Type III Foam Rubber	
	G 1	G 2	G 3	G 4	G 5	G 6
8 oz.	77.8	78.1	85.9	86.7	88.8	93.8
10 oz.	89.7					
12 oz.	87.9					

Comparison of the Different Types of 8 oz. Boxing Gloves.

Pre-Test Results. There were significant differences at the .05 level between the three types of gloves during the pre-test. The difference between type I and type III was significant at the .01 level. There was also a significant difference at the .05 level between type I and type II. No significant difference was found between types II and III. No significant intra-type difference was found between the gloves in type I and II but in type III a significant difference at the .01 level was found between gloves 5 and 6.

TABLE II

ANALYSIS OF VARIANCE OF DIFFERENCES BETWEEN TYPES OF GLOVES.

Source of Variance	Sum of Squares	df	Mean Square	F
Types	723.97	2	361.98	21.11*
Error (a)	51.43	3	17.14	
Trials	1.07	3	.36	.86
Types x Trials	1.59	6	.27	.63
Error (b)	3.76	9	.42	
Total	781.82	23		

* significant at the .05 level of confidence.

Endurance Test Results. There were significant differences at the .01 level between the three different types of gloves after one hundred blows. Significant differences at the .01 level were found between the following:

1. Glove 2 (type I) and glove 5 (type III).
2. Glove 2 (type I) and glove 4 (type II).
3. Glove 5 and glove 6 (both type III gloves).

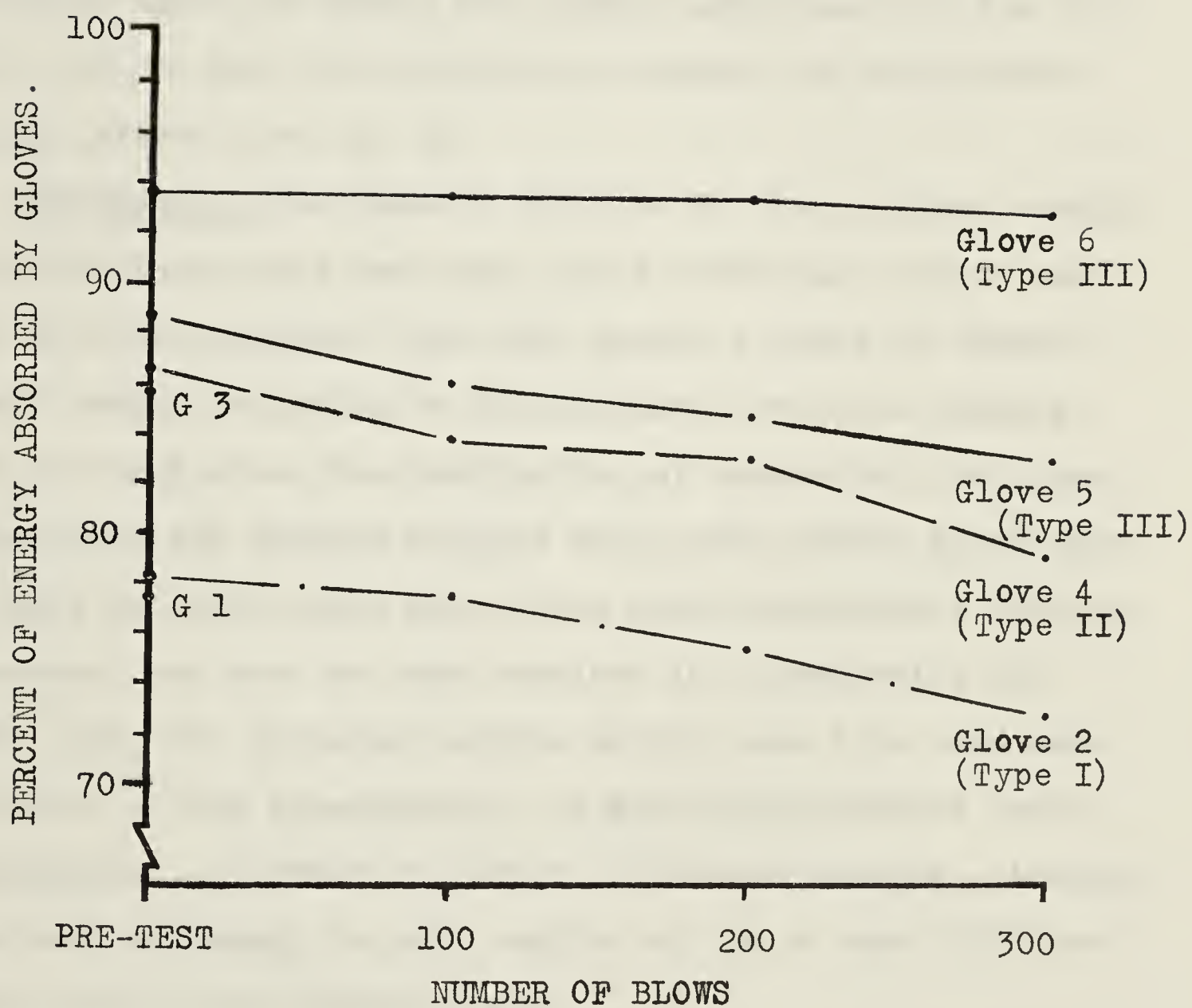


FIGURE VI. DETERIORATION OF THE EIGHT OZ. GLOVES DURING THE ENDURANCE TEST.

There was also a significant difference at the .05 level between glove 4 (type II) and glove 5 (type III).

After two hundred blows, there were still significant differences at the .01 level between the three types of boxing gloves. The level of significance of the differences between the gloves remained the same.

Following three hundred blows, the differences between the three types of gloves were again significant at the .01 level and so were the differences between the four gloves tested (gloves 2, 4, 5, 6).

Discussion. The results obtained at the pre-test session indicated that there was very little difference within each type of glove studied. They also showed a trend to absorb impact energy according to the different types of padding used in the gloves. The combination of coarse hair and foam rubber gave the poorest results while foam rubber alone gave the best one and coarse hair alone gave intermediate results. Of course, one must be very cautious in interpreting the above. Only two different gloves within each type were made available to the experimenter, as many manufacturers failed to cooperate. In order to obtain definitive results, it would have been necessary to test samples of ten or more different gloves within the various types.

From the above, one fact is apparent. More research and experimenting are needed to produce a better boxing glove padding. Glove 6, which was padded by the experimenter with a combination of two foam rubbers proved to be the best

glove tested, absorbing the most impact energy. After an endurance test of 300 blows, this glove was still superior to the others, even during their pre-test. Furthermore, it depreciated only 0.8% after 300 blows. As far as the other types of gloves were concerned, the combination of coarse hair and foam rubber which were the poorest during the pre-test, depreciated 2.4% less than the coarse hair during the actual test. This may imply that if coarse hair should remain the traditional basic material for boxing glove padding, it would depreciate slower if a piece of foam rubber were placed on top of it, and this would further reduce the chance of displacing or breaking the padding.

It was observed by the experimenter that the coarse hair in the different gloves studied, looked somewhat different in color and in resiliency. This may mean that the difference in coloring of the coarse hair is indicative of different properties, which may have influenced the results.

TABLE III

SURFACE OF IMPACT OF THE DIFFERENT GLOVES
IN SQUARE INCHES AFTER 4 BLOWS.

Weight	Type I Coarse Hair and Foam Rubber		Type II Coarse Hair		Type III Foam Rubber	
	G 1	G 2	G 3	G 4	G 5	G 6
8 oz.	14.79	14.20	15.125	16.355	13.765	13.225
10 oz.	20.125					
12 oz.	22.88					

Surface of Impact. From table III it can be seen that the foam rubber gloves had the smallest surface of impact. Thus, their capacity to absorb impact energy does not seem to be due to the spread of the force of impact but rather to the resiliency of the material itself.

Comparison of 8, 10, 12 oz. Gloves Padded With a Combination of Foam Rubber and Coarse Hair.

To accomplish the above, the pre-test results of glove 2 (type I) were used as well as those of the ten ounce glove used for a boxing tournament and a new 12 oz. one. It was the intention of the experimenter to study the fatigue effect of a tournament on some 10 oz. gloves. Unfortunately, some damage to the metal target prevented the use of the recordings taken before the tournament. Consequently, only recordings with target # 2, which was used for all the tests, were retained.

Results. There were significant differences at the .01 level between the 8 and 12 oz. gloves and between the 8 and 10 oz. gloves, which were used for 6 fights. The 10 oz. glove could still absorb 1.8% more impact energy than a new 12 oz. glove. This difference was not found to be statistically significant.

Discussion. The apparent superiority of the 10 oz. glove over the 12 oz., after 6 fights, might imply that there is an optimum weight for a boxing glove, or that the added weight of extra padding is not well distributed. This does not satisfy the aim of padding a boxing glove, which is to

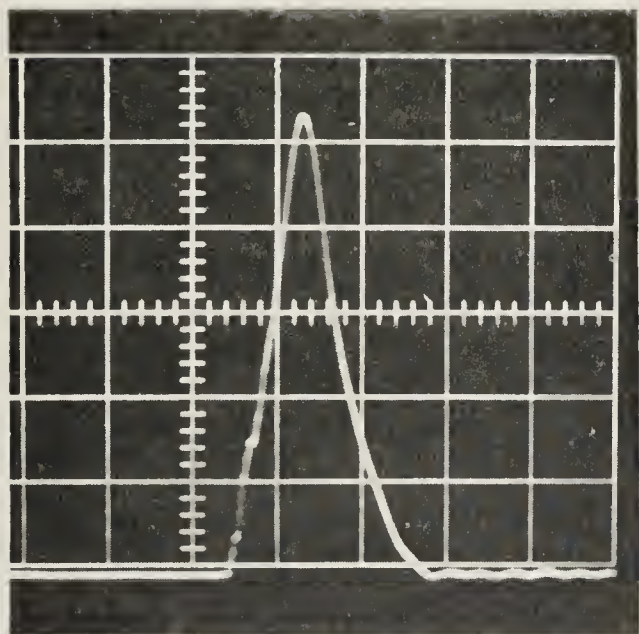


Figure VII. Oscilloscope deflection given by a type I 8 oz. glove during pre-test.

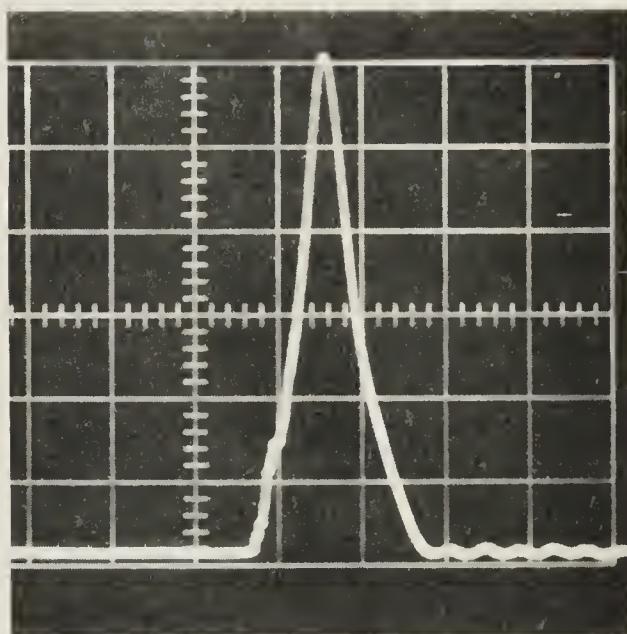


Figure VIII. Oscilloscope deflection by the same glove after 300 blows.

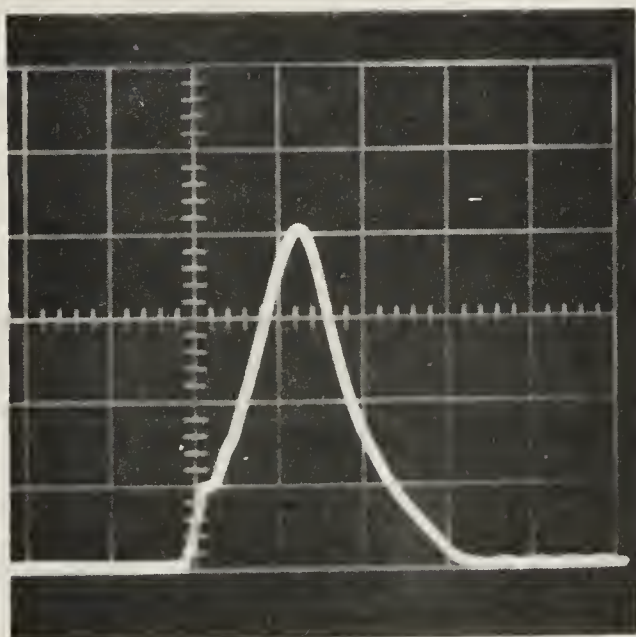


Figure IX. Oscilloscope deflection given by a type I 10 oz. glove after 6 fights.

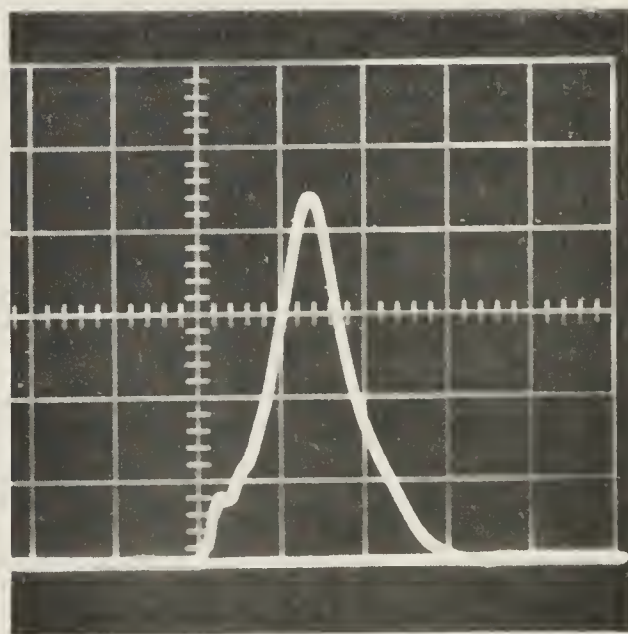


Figure X. Oscilloscope deflection given by a type I 12 oz. glove during pre-test.

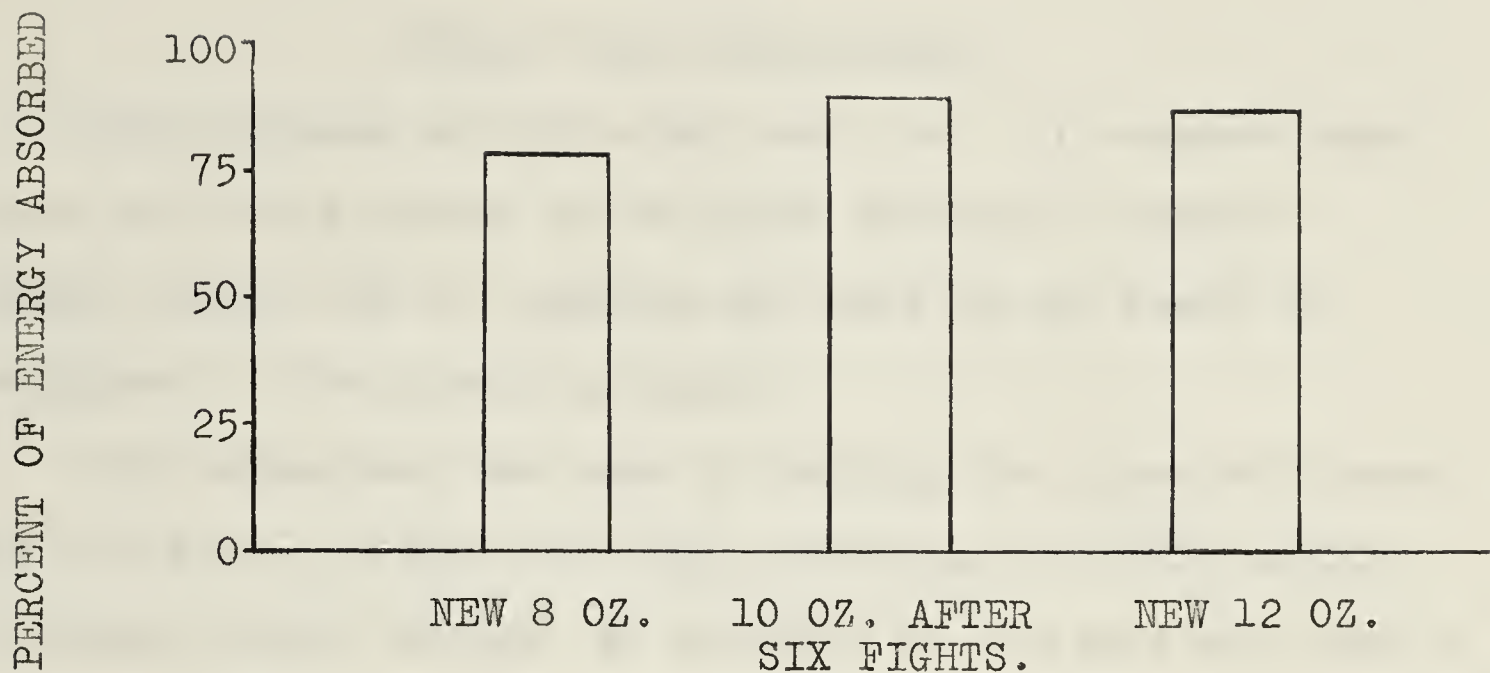


FIGURE XI. DIFFERENCE IN ENERGY ABSORPTION OF DIFFERENT TYPE I GLOVES.

further reduce the impact or force of a blow. A consequence of this in Amateur Boxing, could be that, due to the extra weight of the boxing gloves, a youngster would tire easily, and then would frantically start swinging punches and lowering his guard, after a few rounds. An increase in padding to reduce the incidence of injury in boxing could therefore result in greater danger for the boxer, especially when it does not serve its purpose to reduce the force of impact of the blow. It should be strongly emphasized that only one glove of each weight was tested. In a study to determine the optimum weight, many gloves of each weight should be included.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purposes of this study were to: (1) compare three types of boxing gloves as to their ability to absorb impact energy and (2) analyze the data on the basis of responses of the gloves at impact.

The comparison was done by ranking the types of gloves and the gloves within each type according to their ability to absorb impact energy. An analysis of variance was used to determine if there were any significant differences between the types of gloves studied. Multiple comparisons in the analysis of variance and t-tests were also used to see if there was any significant differences between each glove within each type tested.

The experimental procedure consisted of having the gloves, which were fitted unto a wooden fist, make contact with a metal target which deflected upon contact. The responses to impact were measured by a strain gauge fixed under the center of the target, and the information was fed into an oscilloscope. The oscillographic tracings resulting from these impacts were photographed by an attached Polaroid camera. The energy absorbed by the glove was then calculated.

The boxing gloves were ranked according to their ability to absorb impact energy.

On the basis of the statistical analysis and within the limitations of the study, the following appear to be justified:

1. All the gloves examined appeared to offer a certain degree of protection.

2. Boxing gloves padded with foam rubber have a superior capacity to absorb impact energy than those padded with coarse hair or with a combination of both foam rubber and coarse hair as outlined in this study.

3. All the gloves showed a degree of deterioration, after an endurance test of 300 blows.

Recommendations.

1. Various assorted types of padding and combinations of them should be tested to determine the most suitable one for boxing gloves.

2. Fatiguing effect from a more prolonged series of impacts on the gloves should be studied.

3. The incidence of cuts and knock outs in actual fights and in training using different types and weights of gloves should be recorded.

4. More research is needed to produce an adequate headgear for boxing. Since the gloves tested absorbed between 75 and 93 per cent of impact energy, it seems that the use of a well-designed head protector would further decrease the incidence of boxing injury.

5. The boxing glove itself may have to be redesigned. It was noticed when taking the surface of impact of the different 8 oz. gloves, that the thumb was often coming in contact with the target. As one knows this is very dangerous for a boxer's eyes in an actual fight. As

suggested by Blonstein (8) it may be safer that the boxer's thumb be an intricate part of the glove rather than being separate. Furthermore it was observed that 10 oz. gloves that had been used for six fights were still superior in absorbing impact energy than a new 12 oz. glove. If this finding could be substantiated on many gloves of each weight it would indicate that the added weight of extra padding fails to serve its purpose; which is to further reduce the impact or force of a blow.

6. In an eight ounce glove, the leather portion weighs the same amount as the padding. Therefore with more research in the area, it may be possible to produce a material lighter than the leather presently in use which would adequately serve the same purpose. The difference in weight could then be added in padding and therefore result in a safer glove for boxers.

7. With respect to foam rubber types of gloves, it would seem better to mold the padding itself, giving it the shape of a semi-closed fist. As it was, the glove tested was made of two different types of foam rubber. Three layers were superimposed and glued together so that only a small inflection was given to the padding. More strength is thus required to clench the fist which further causes local fatigue in certain muscles.

8. It would seem logical to modify the rule concerning boxing gloves. That is the glove to be used should be determined on the basis of padding rather than weight alone.

Certain absorption factors with regard to padding must be taken into consideration making such a decision.

9. For comparable results, standardized testing equipment should be used in future testing of this kind. Mass, dimension and angle of release of the pendulum, as well as size, thickness and type of metal used in the construction of the target to be used.

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APPENDIX

APPENDIX A
STATISTICAL TREATMENT

STATISTICAL TREATMENT

Study Design. Six 8 oz. boxing gloves of six different pairs, classified in three types, were studied along with a pair of 10 and 12 oz. The following comparisons were made:

1. An inter-types comparison with the 8 oz. gloves.
2. An intra-type comparison with the same gloves.
3. A comparison between the best four 8 oz. gloves after the first, second and third hundred blows.
4. A comparison between a new 8, 10 oz. that had been used for six fights and a new 12 oz., all type I gloves.

Statistical Procedure.

Trend Analysis of Types. The trend analysis, as described by Edwards (12:227), was used to test the significance of the inter-types differences after the pre-test and at three different stages of the endurance test, as well as for the 8, 10 and 12 oz. gloves comparison. An example of the method is illustrated below.

Trials	Type I		Type II		Type III		Total
	G 1	G 2	G 3	G 4	G 5	G 6	
1	78.1	77.0	86.3	86.3	89.3	93.9	510.9
2	78.1	78.1	84.7	87.1	88.6	93.4	510.0
3	77.0	78.1	86.3	86.3	88.6	93.9	510.2
4	78.1	79.2	86.3	87.1	88.6	93.9	513.2
Total	311.3	312.4	343.6	346.8	355.1	375.1	2044.3
Mean	77.8	78.1	85.9	86.7	88.8	93.8	

Sums of Squares. (SS)

$$1) \text{ Correction term (C.T.)} = \frac{2044.3^2}{24} = 174,131.77$$

$$2) \text{ Total SS} = (78.1^2 + 78.1^2 + \dots + 93.9^2) - \text{C.T.}$$

$$= 781.83$$

$$3) \text{ Types SS} = 1/8 (623.7^2 + 690.4^2 + 730.2^2) - \text{C.T.}$$

$$= 723.97$$

$$4) \text{ Gloves SS} = 1/4 (311.3^2 + 312.4^2 + \dots + 375.1^2) - \text{C.T.}$$

$$= 775.40$$

$$5) \text{ Trials SS} = 1/6 (510.9^2 + 510.0^2 + 510.2^2 + 513.2^2) - \text{C.T.}$$

$$= 1.08$$

$$6) \text{ Gloves x Trials SS}$$

$$= 781.83 - (775.40 + 1.08)$$

$$= 5.36$$

Degrees of Freedom.

$$\text{Total} = 23$$

$$\text{Gloves} = 5 \begin{bmatrix} 2 \text{ types} \\ 3 \text{ residual} \end{bmatrix}$$

$$\text{Trials} = 3$$

$$\text{Gloves x Trials} = 15 \begin{bmatrix} 5 \text{ types x trials} \\ 3 \text{ residual} \end{bmatrix}$$

Partitioning SS (Gloves).

$$\text{SS (types)} = 1/8 (623.7^2 + 690.4^2 + 730.2^2) - \text{C.T.}$$

$$= 723.97$$

$$\text{Residual} = \text{SS (gloves)} - \text{SS (types)}$$

$$= 775.40 - 723.97$$

$$= 51.43$$

Partitioning SS (Gloves x Trials).

TABLE B

Trials	Types		
	B ₁	B ₂	B ₃
1	155.1	172.6	183.2
2	156.2	171.8	182.0
3	155.1	172.6	182.5
4	157.3	173.4	182.5
Total	623.7	690.4	730.2

SS (between cells in table B)

$$= 1/2 (155.1^2 + 156.2^2 + \dots + 182.5^2) - C.T.$$

$$= 726.63$$

$$SS (types \times trials) = SS (cells) - SS (types) - SS (trials)$$

$$= 726.63 - (723.97 + 1.08)$$

$$= 1.59$$

$$Residual = SS (gloves \times trials) - SS (types \times trials)$$

$$= 5.36 - 1.59$$

$$= 3.77$$

Analysis (Trend).

Source of Variance	SS	d.f.	M.S.	F.
Types	723.97	2	361.98	21.11*
Error (a)	51.43	3	17.14	
Trials	1.08	3	0.36	0.86
Types x trials	1.59	6	0.27	0.63
Error (b)	3.76	9	0.42	
Total	781.83	23		

* Significant at the .05 level of confidence.

Multiple Comparisons in the analysis of Variance.

The multiple comparisons in the analysis of variance technique outlined by Edwards (12:136), was used to test the significances of inter-types and/or inter-gloves differences. An example of the method is illustrated below.

1. Arrange the means in order of magnitude.

77.96 86.30 91.28

2. Find standard error of a single mean given by formula.

$$S_{\bar{x}} = \frac{S}{\sqrt{n}} \quad \left(S = \sqrt{M.S. \text{ of Error (a) of the analysis of variance}} \right)$$

$$\quad \quad \quad \left(n = \text{number of observations on which the mean is based} \right)$$

$$= \frac{\sqrt{17.4}}{\sqrt{4}} = 1.46$$

3. From table X in textbook (.05 level)

$$(k = 2) = 4.501$$

$$(k = 3) = 4.516$$

$$4.501 \times 1.46 = 6.57$$

$$4.516 \times 1.46 = 6.59$$

4.	Type I	Type II	Type III	Shortest significant range (.05 level)
Mean	77.96	86.30	91.28	
		8.34*	13.32**	$R_2 = 6.57$
			4.98	$R_3 = 6.59$

** Significant at the .01 level of confidence.

* Significant at the .05 level of confidence.

APPENDIX B RAW DATA

SCOPE DEFLECTION FROM THE DIFFERENT GLOVES IN Mm.

8 OZ. GLOVES

Number of Blows	Type I		Type II		Type III	
	Coarse Hair and Foam Rubber		Coarse Hair		Foam Rubber	
	G 1	G 2	G 3	G 4	G 5	G 6
1	55	56	46	46	42	34
2	55	55	48	45	43	35
3	56	55	46	46	43	34
4	55	54	46	45	43	34
After 100		55		49	46	34
		56		49	47	35
After 200		58		50	48	35
		57		50	48	35
After 300		60		54	50	36
		59		54	50	36

10 OZ. GLOVES (AFTER 6 FIGHTS)

1	45[	Right Glove
2	40[	
3	39[	Left Glove
4	41[	

12 OZ. GLOVE

1	44
2	44
3	44
4	44

SURFACE OF IMPACT OF THE DIFFERENT GLOVES IN SQUARE INCHES.

8 OZ. GLOVES

Number of Blows	Coarse Hair and Foam Rubber		Coarse Hair		Foam Rubber	
	G 1	G 2	G 3	G 4	G 5	G 6
1	14.97	14.19	15.02	16.37	13.92	13.19
2	14.61	14.21	15.23	16.34	13.61	13.26

10 OZ. GLOVES

1	20.22
2	20.03

12 OZ. GLOVE

1	22.88
2	22.88

APPENDIX C
NAMES AND ADDRESSES OF PEOPLE CONTACTED FOR INFORMATION

PEOPLE CONTACTED FOR INFORMATION.

Here are the names and addresses of the people and the companies with whom the writer corresponded for information. In the bracket is indicated the number of letters sent to them.

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Coney Island Station,
Brooklyn, N.Y. 11224.

Triolo, Mr. Mike, (1)
Boxing Coach of the Catholic Youth Organization,
1170 W. Jackson Blvd.,
Chicago, Illinois.

U.S. Army Sports Branch, (1)
c/o Mr. George M. Wilson,
Deputy Chief,
Office of the Adjutant General,
Washington 25, D.C.

Weaterall, Mr. T.L., (1)
APTC, Camp Borden,
Ontario.

Wellinger & Dunn Leather Goods Ltd., (2)
350 Sorauden Avenue,
Toronto 3, Ontario.
c/o Mr. C.R. Ostrander.

Wilson Sporting Goods Company Ltd., (3)
2233 West Street,
River Grove, Illinois.
c/o Mr. Jack Havey.

APPENDIX D

SOME LETTERS OF INTEREST RECEIVED

24/6/64

Dear Robert,

We are in the
process of manufacturing the
latest pneumatic gloves and
as soon as they are ready.

I will send you a pair.

You might also be interested
to receive a specimen of the
latest pneumatic headgear.

With best wishes,

Yours sincerely

Lew Almonstein

Sen. Hon. Med. Officer A.B.A
General Secretary Medical
Commission A.I.B.A.

128 HARLEY St.
LONDON W1
ENGLAND

18/9/64

FROM
DR. J. L. BLONSTEIN

My dear Pina,

The "final" pneumatic glove should be ready any day. The weight is $7\frac{3}{4}$ y.
I will certainly send you a glove as soon as it is ready.

Yours sincerely

J. L. Blonstein

QANTAS EMPIRE AIRWAYS

30/1/65

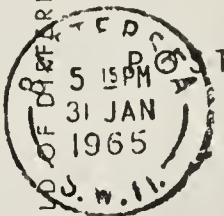
Dear Pina,

Thank you for your letter and enclosures. I can only say that the manufacturers have not yet put the glove on the market but you are definitely in the priority list.

Yours sincerely
J. L. Blonstein

QANTAS BOEING 707 V-JET
Cruises at 580 m.p.h.; carries 90 to 120 passengers and 5 tons of cargo. Wing-span 130' 10", overall length 134' 6".

FLY QANTAS — THERE'S A WORLD OF DIFFERENCE



Robert Pina Esq.

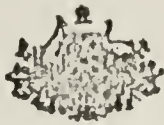
10138 - 112nd St.

Edmonton

Alberta

Canada

Printed in Australia



The Amateur Boxing Union of Australia

AFFILIATED WITH
ASSOCIATION INTERNATIONALE DE BOXE AMATEUR
AUSTRALIAN OLYMPIC FEDERATION AUSTRALIAN, BRITISH EMPIRE & COMMONWEALTH GAMES ASSN.

President:

E. S. TANNER, Esq., C.B.E., E.D., M.P.

Vice-President:

R. MARK,
N.S.W.

Executive:

C. BAXTER (Qld.)
R. JACKSON (Tas.)
C. GRIFFITH (W.A.)
H. WRATHALL (Vic.)
G. DICKINSON (S.A.)
P. HYNES (N.S.W.)

A. TUNSTALL, Hon. Secretary-Treasurer
27 South Avenue, Double Bay
Sydney, Australia

Phone: Business MX 3908. Private FB 3129

23rd May, 1964.

R. Piau, Esq.,
9675, 87th Ave,
Edmonton, Alberta,
CANADA.

Dear Sir,

I acknowledge receipt of your letter of the 6th inst, for who which I thank you.

In reply I wish to advise that while the above Union was interested in the use of Pneumatic Gloves it was found that the Gloves that were being used were not up to the requirements expected.

The main difficulty experienced was that the Gloves had to be placed on the competitors hands first and then inflated by mouth to bring the glove up to size. This as you can well understand is a most unsatisfactory situation, and as you can imagine there was no way of gaugeing the amount of pressure in each glove. Again if to much air was blown into the glove it was impossible to close the fist properly which in turn meant that a boxer was unable to deliver a proper punch.

It was also noticed that when a blow was struck around the eyes the glove had a tendency to slide across the eye and bruise the face. I had this rectified by asking the manufacturers to insert a leather strip inside the glove so that the competitors would be able to grip same in the palm of the hand and thus prevent the glove from slipping all the time.

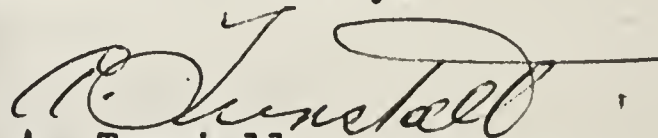
The idea of the glove is quite sound and I think if the inflation part could be overcome then the gloves would be ideal. As you

As you can readily understand the amount of air pressure in the bladder of the glove is very low, and it is practically impossible under the present system of blowing by mouth to regulate same. I suggested that if a gauge could be used to inflate the gloves and regulate the amount in each glove then the problem would be solved. The manufacturers thought that this would be almost impossible and so gave the idea away, and consequently no more gloves were made.

All these experiments took place about three or four years ago and I'm afraid that we do not have any of the gloves left as they were thrown away or returned to the manufacturer.

Sorry that I cannot assist you in this matter my friend but I trust that the information supplied may be of some help to you.

Yours Faithfully.


A. Tunstall.
Hon. Secretary/Treasurer.

ФЕДЕРАЦИЯ БОКСА СССР

THE BOXING FEDERATION OF THE U.S.S.R. * LA FEDERATION DE BOXE DE
L'U.R.S.S. * FEDERATION BOXEN DER UDSSR * FEDERACION
DE BOXEO DE LA URSS

Адрес: Москва 69, Скатертный переулок 4
Телеграф. адрес: Москва, Союзспорт.
Тел. К 4-84-65

Address: Moscow 69, Skatertnyl pereulok 4
Telegrams: Moscow, Sojuzsport. Tel. K 4-84-65

№. _____

„ 5 „ января 1965 г.

Уважаемый господин ПИАУ,

Подтверждаем получение Вашего
письма от 24 ноября 1964 года.

Доводим до Вашего сведения, что
советские боксеры пользуются перчатка-
ми, набитыми конским волосом, весом 10
унций, а спортсмены тяжелого веса - пер-
чатками, весом 12 унций.

Одновременно направляем Вам
"Правила соревнований", которые, воз-
можно, будут представлять для Вас ин-
терес.

С уважением и наилучшими но-
вогодними пожеланиями

Г. ЗЫБАЛОВ

Ответственный секретарь.

Г-ну Р. ПИАУ

ЭДМОНТОН
КАНАДА

B29838